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(54) **GAS TURBINE ENGINE COMPONENT**

BAUTEIL EINES GASTURBINENTRIEBWERKS

COMPOSANT DE MOTEUR À TURBINE À GAZ

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Description

BACKGROUND OF THE INVENTION

[0001] This application relates to an airfoil utilized in a gas turbine engine component.

[0002] Gas turbine engines typically include a plurality of sections mounted in series. A fan may deliver air to a compressor section. The compressor section compresses that air and delivers it into a combustion section at which it is mixed with fuel and combusted. Products of this combustion pass downstream over turbine rotors, and through turbine vanes. The rotors are driven to rotate by the products of combustion. Typically, the vanes include airfoils fixed between opposed radially inward and radially outward end walls. Since the vanes are mounted in the path of the products of combustion, they are subject to extremely high temperature. Thus, cooling air is typically delivered within the airfoil, and circulated to various locations on the skin of the vanes. One location to which the cooling air is directed is through a so-called showerhead array of cooling holes on a leading edge of the airfoil.

[0003] Typically, the airfoil merges into the end walls with only a very small radius of curvature, or fillet. Thus, the connection of the airfoil into the end wall could be approximated as less than 5% of the radial span of the airfoil. In such components, a flow field phenomenon known as a "bow wake" occurs wherein air has a negative pressure gradient. The gradient transports hot mid span gases onto the end wall. To address the bow wake, additional cooling holes have been formed in the end wall.

[0004] Another type of airfoil has a so-called "large fillet," or curve, merging the airfoil into the end walls. As an example, the large fillet would extend over more than 5% of the radial length of the airfoil. With such an airfoil, the effect of bow wake is reduced or eliminated. The known large fillet airfoils have typically included a showerhead that extends through the radial extent of the airfoil.

[0005] EP 1688587 A2 discloses a gas turbine engine component in accordance with the preamble of claim 1.

[0006] EP 1669544 A1 and EP 1647672 A2 also disclose airfoils having fillets including cooling holes formed therethrough.

SUMMARY OF THE INVENTION

[0007] The present invention provides a gas turbine engine component as set forth in claim 1.

[0008] In a disclosed embodiment of this invention, a large fillet airfoil is provided with a fanned cooling hole array in the fillet area. The cooling holes fan circumferentially outwardly from a showerhead such that a larger surface area is covered in the fillet.

[0009] These and other features of the present invention can be best understood from the following specification and drawings, the following of which is a brief description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

Figure 1 shows an example gas turbine engine.

Figure 2 is a perspective view of a vane from the gas turbine engine of Figure 1.

Figure 3 is a side view of a large fillet airfoil.

Figure 4 shows a cooling hole array in a large fillet airfoil.

Figure 5 is a cross-sectional view through a portion of the large fillet.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] A gas turbine engine 10, such as a turbofan gas turbine engine, circumferentially disposed about an engine centerline, or axial centerline axis 12 is shown in Figure 1. The engine 10 includes a fan 14, compressor sections 15 and 16, a combustion section 18 and a turbine 20. As is well known in the art, air compressed in the compressor 15/16 is mixed with fuel and burned in the combustion section 18 and expanded in turbine 20. The turbine 20 includes rotors 22 and 24, which rotate in response to the expansion. The turbine 20 comprises alternating rows of rotary airfoils or blades 26 and static airfoils or vanes 28. In fact, this view is quite schematic, and blades 26 and vanes 28 are actually removable. It should be understood that this view is included simply to provide a basic understanding of the sections in a gas turbine engine, and not to limit the invention. This invention extends to all types of turbine engines with axial turbines for all types of applications.

[0012] As shown in Figure 2, one type of vane is a vane 40 provided with a large fillet. The large fillet 44 is formed to connect an airfoil 41 into end walls 43 and 39. As shown, a nominal portion of the airfoil 41 merges into end wall 43 through the large fillet 44. An upstream end 200 of the vane is shown, as is a downstream end 202 for orientation. As can be appreciated from Figure 2, essentially, the large fillet 44 curves upstream from the airfoil 41 into the end walls 43 and 39, and also curves circumferentially to each side of the airfoil 41.

[0013] As shown in Figure 3, the large fillet extends for a relatively great amount of a radial extent of the airfoil. For purposes of this measurement, the large fillet is treated as part of the radial extent of the airfoil. As shown in Figure 3, the fillet 44 extends for approximately 25% of the overall radial extent, or span. Of course, this amount is only one example. The term "large fillet" can be taken as anything over 5% of the span.

[0014] As shown in Figure 4, the vane 40 includes the airfoil 41 merging into the large fillet 44. So-called showerhead holes 60 extend through the airfoil portion 41. As can be appreciated, the showerhead holes 60 tend to extend through several rows spaced circumferentially by a small amount. Planes 62 can be defined by each circumferentially outermost row of showerhead holes 60.

[0015] As can be appreciated from Figure 4, within the large fillet 44, additional holes are formed. Holes fan circumferentially outwardly in both directions to define planes 64. Several rings are defined including rings 1, 2, and 3 as illustrated in Figure 4, and each ring includes more holes in the large fillet than the prior ring. Thus, five holes 66 are illustrated in ring 1, with 6 holes 68 in ring 2, and 7 holes 70 in ring 3. Of course, any number of holes can be utilized. The main feature is to fan the holes circumferentially outwardly towards the curved sides 72 of the large fillet and beyond the planes 62 defined by the showerhead holes. In addition, as can be appreciated, the holes 66, 68, and 70 are staggered, such that they will cover a larger circumferential portion of the surface area.

[0016] In addition, the size of the holes in the large fillet 44 may be smaller than the holes in the airfoil 41. The large fillet 44 will likely be dealing with cooler gasses than will the area having the showerhead, and thus the smaller holes may be acceptable. On the other hand, all holes could be the same size. Also, the holes in the large fillet 44 could be larger than those in airfoil 41. The size of the holes is a function of how much cooling is required given the radial temperature profile from the products of combustion to which the airfoil is exposed. Also, manufacturing capabilities and gross size of the airfoil do come into play as well. Because end walls are typically cooler then the mid span, an optimized design may have the holes become smaller as you approach the end wall.

[0017] Figure 5 shows another feature, wherein the holes 102 in the fillet 44 can be seen to exit at an angle θ such that the exiting air is driven back against the outer skin of the large fillet by the products of combustion approaching the airfoil 41. Holes may exit the fillet at any angle but to reduce blow off and thus increase film adhesion and to increase the internal surface area of the film hole, the optimal configuration is to produce an array with the shallowest surface angles. This angle θ is shown as being less than 90° to achieve this benefit.

[0018] Film hole exit diffusion can be used to further enhance film effectiveness. This could include something other than constant cross section round holes. Instead, the holes can have something like a simple or compound angles to provide a diffusion angle.

[0019] The fanning of the cooling hole array provides convective cooling for the largest portion of the fillet volume and minimizes the amount of cooling required. It also allows for the greatest amount of overall film coverage due to hole staggering along streamlines.

[0020] In addition to cooling the airfoil, a potential benefit of the fillet cooling hole array results from the additional air introduced near the end walls of the gas path. At these locations, a rich oxygen environment increases the likelihood that combustion is completed prior to entering the turbine. This has the potential to reduce the likelihood of unwanted downstream thermal phenomena when running at fuel rich operating points.

[0021] In sum, a large fillet merges an airfoil into an end wall for a gas turbine engine component. While disclosed in a turbine vane, the invention would extend to blades. While a double vane is shown, the invention also extends to single vanes. The large fillet is provided with a cooling hole array, which fans outwardly from a cooling hole array in a nominal portion of the airfoil. In this manner, the large fillet is provided with better cooling than was the case in the prior art.

[0022] Although an embodiment of this invention has been disclosed, a worker of ordinary skill in this art would recognize that certain modifications would come within the scope of this invention. For that reason, the following claims should be studied to determine the true scope and content of this invention.

Claims

1. A gas turbine engine component (40) comprising:

   an airfoil (41) extending through a radial extent, and having a circumferential dimension defined between opposed side walls, and a nominal portion merging into an end wall (39;43) through a fillet (44) that extends over a radial extent of greater than 5% of said radial extent of the airfoil (41); and further comprising
   cooling holes (60,66,68,70;102) formed in said nominal portion and in said fillet (44), said cooling holes (60) in said nominal portion extending for a first circumferential extent, and said cooling holes (60,68,70;102) in said fillet (44) extending for a second circumferential extent that is greater than said first circumferential extent; **characterised in that**
   said cooling holes (66,68,70;102) in said fillet (44) are formed in a plurality of radially spaced rings (1,2,3); and
   wherein there are at least three of said radially spaced rings (1,2,3), and a radially spaced ring (3) closest to said end wall (39;43) has more cooling holes (70) than a radially spaced ring (2) spaced at an intermediate distance from said end wall (39;43), and said radially spaced ring (2) positioned at an intermediate distance has more cooling holes (68) than a radially spaced ring (1) spaced furthest from said end wall (39;43).

2. The gas turbine engine component as set forth in claim 1, wherein said fillet (44) curves in an upstream direction from said nominal portion, and also curves circumferentially outwardly to each side of said nominal portion to merge into said end wall (39;43).

3. The gas turbine engine component as set forth in claim 1 or 2, wherein said cooling holes

(66,68,70;102) in said fillet (44) exit said fillet (44) at an angle (θ) measured to a tangent of an outer surface of the fillet (44) extending towards the nominal portion, with the angle being less than or equal to 90°.

4. The gas turbine engine component as set forth in any preceding claim, wherein said cooling holes (60) in said nominal portion have a larger cross-sectional area than said cooling holes (66,68,70) in said fillet (44).

5. The gas turbine engine component as set forth in any preceding claim, wherein said component (40) is a stationary vane for a turbine section.

Patentansprüche

1. Bauteil (40) eines Gasturbinentriebwerks, umfassend:

   ein Schaufelblatt (41), das sich durch eine radiale Ausdehnung erstreckt und das eine Umfangsabmessung, die zwischen gegenüberliegenden Seitenwänden definiert wird, und einen Nennabschnitt aufweist, der über eine Rundung (44), die sich über eine radiale Ausdehnung von mehr als 5 % der radialen Ausdehnung des Schaufelblatts (41) erstreckt, in eine Stirnwand (39; 43) übergeht; und ferner umfassend Kühllöcher (60, 66, 68, 70; 102), die in dem Nennabschnitt und in der Rundung (44) ausgebildet sind, wobei sich die Kühllöcher (60) in dem Nennabschnitt über eine erste Umfangsausdehnung erstrecken und wobei sich die Kühllöcher (60, 68, 70; 102) in der Rundung (44) über eine zweite Umfangsausdehnung erstrecken, die größer als die erste Umfangsausdehnung ist; **dadurch gekennzeichnet, dass** die Kühllöcher (66, 68, 70; 102) in der Rundung (44) in einer Vielzahl von radial beabstandeten Ringen (1, 2, 3) ausgebildet sind; und

   wobei mindestens drei der radial beabstandeten Ringe (1, 2, 3) vorliegen und ein radial beabstandeter Ring (3), der der Stirnwand (39; 43) am nächsten ist, mehr Kühllöcher (70) aufweist als ein radial beabstandeter Ring (2), der bei einem Zwischenabstand von der Stirnwand (39; 43) beabstandet ist, und der radial beabstandete Ring (2), der bei einem Zwischenabstand positioniert ist, mehr Kühllöcher (68) aufweist als ein radial beabstandeter Ring (1), der am weitesten von der Stirnwand (39; 43) beabstandet ist.

2. Bauteil eines Gasturbinentriebwerks nach Anspruch 1, wobei sich die Rundung (44) von dem Nennabschnitt in eine stromaufwärtige Richtung wölbt und sich ebenfalls in Umfangsrichtung nach außen zu jeder Seite des Nennabschnitts wölbt, um in die Stirnwand (39; 43) überzugehen.

3. Bauteil eines Gasturbinentriebwerks nach Anspruch 1 oder 2, wobei die Kühllöcher (66, 68, 70; 102) in der Rundung (44) bei einem Winkel (θ), der zu einer Tangente einer Außenfläche der Rundung (44), die sich in Richtung des Nennabschnitts erstreckt, gemessen wird, aus der Rundung (44) austreten, wobei der Winkel weniger als oder gleich 90° beträgt.

4. Bauteil eines Gasturbinentriebwerks nach einem der vorhergehenden Ansprüche, wobei die Kühllöcher (60) in dem Nennabschnitt einen größeren Querschnittsbereich aufweisen als die Kühllöcher (66, 68, 70) in der Rundung (44).

5. Bauteil eines Gasturbinentriebwerks nach einem der vorhergehenden Ansprüche, wobei das Bauteil (40) eine stationäre Leitschaufel für einen Turbinenabschnitt ist.

Revendications

1. Composant de moteur à turbine à gaz (40) comprenant :

   un profil aérodynamique (41) s'étendant à travers une étendue radiale, et ayant une dimension circonférentielle définie entre des parois latérales opposées, et une partie nominale fusionnant en une paroi d'extrémité (39 ; 43) à travers un congé de raccordement (44) qui s'étend sur une étendue radiale supérieure à 5 % de ladite étendue radiale du profil aérodynamique (41) ; et comprenant en outre

   des trous de refroidissement (60, 66, 68, 70 ; 102) formés dans ladite partie nominale et dans ledit congé de raccordement (44), lesdits trous de refroidissement (60) dans ladite partie nominale s'étendant sur une première étendue circonférentielle, et lesdits trous de refroidissement (60, 68, 70 ; 102) dans ledit congé de raccordement (44) s'étendant sur une seconde étendue circonférentielle qui est supérieure à ladite première étendue circonférentielle ; **caractérisé en ce que**

   lesdits trous de refroidissement (66, 68, 70 ; 102) dans ledit congé de raccordement (44) sont formés en une pluralité d'anneaux radialement espacés (1, 2, 3) ; et

   dans lequel il y a au moins trois desdits anneaux radialement espacés (1, 2, 3), et un anneau radialement espacé (3) le plus proche de ladite paroi d'extrémité (39; 43) a plus de trous de refroidissement (70) qu'un anneau radialement espacé (2) espacé d'au moins une distance intermédiaire de ladite paroi d'extrémité (39; 43), et ledit anneau radialement espacé (2) positionné à une distance intermédiaire a plus de trous de refroidissement (68) qu'un anneau radialement espacé (1) le plus espacé de ladite paroi d'extrémité (39 ; 43).

2. Composant de moteur à turbine à gaz selon la revendication 1, dans lequel ledit congé de raccordement (44) se courbe dans une direction amont à partir de ladite partie nominale, et se courbe également de manière circonférentielle vers l'extérieur de chaque côté de ladite partie nominale pour fusionner en ladite paroi d'extrémité (39 ; 43).

3. Composant de moteur à turbine à gaz selon la revendication 1 ou 2, dans lequel lesdits trous de refroidissement (66, 68, 70; 102) dans ledit congé de raccordement (44) sortent dudit congé de raccordement (44) selon un angle (θ) mesuré à une tangente d'une surface extérieure du congé de raccordement (44) s'étendant vers la partie nominale, avec l'angle étant inférieur ou égal à 90°.

4. Composant de moteur à turbine à gaz selon une quelconque revendication précédente, dans lequel lesdits trous de refroidissement (60) dans ladite partie nominale ont une zone de section transversale supérieure par rapport auxdits trous de refroidissement (66, 68, 70) dans ledit congé de raccordement (44).

5. Composant de moteur à turbine à gaz selon une quelconque revendication précédente, dans lequel ledit composant (40) est une aube stationnaire pour une section de turbine.

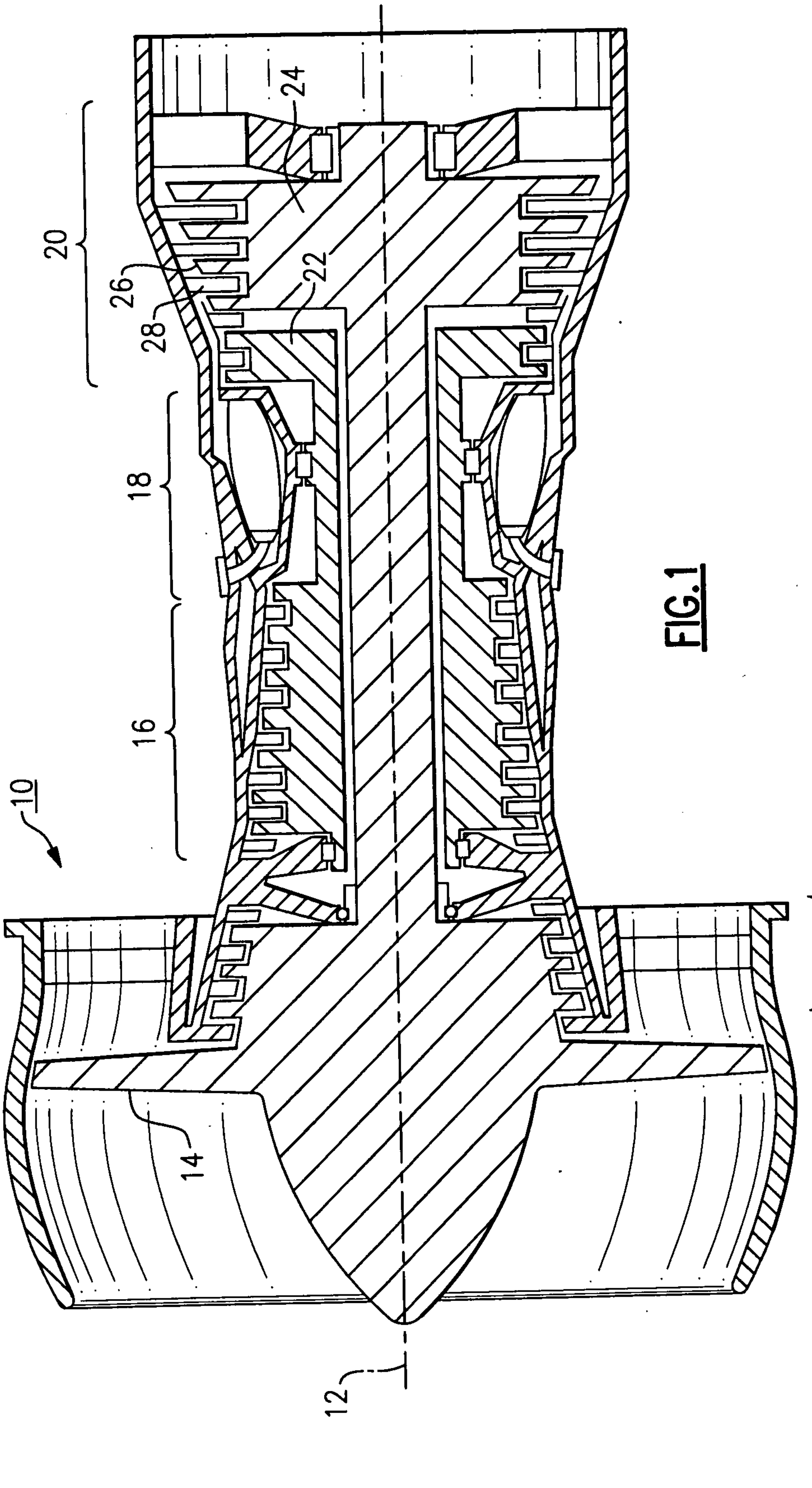

FIG.1

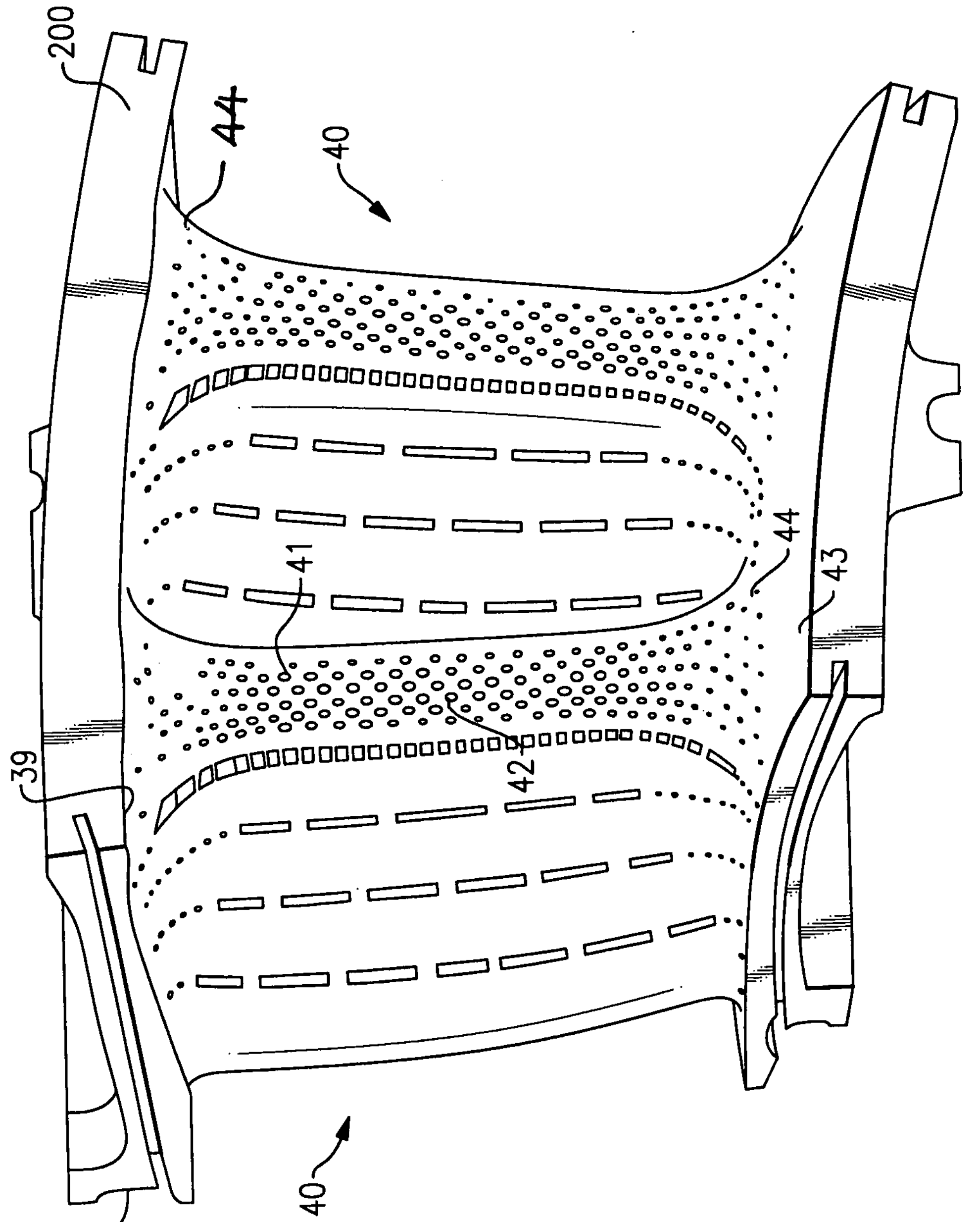

FIG.2

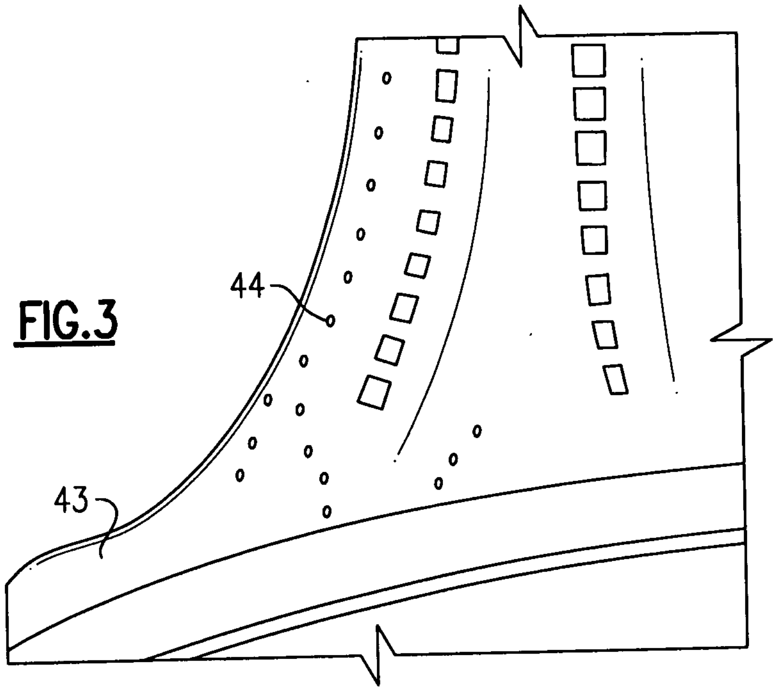

FIG.3

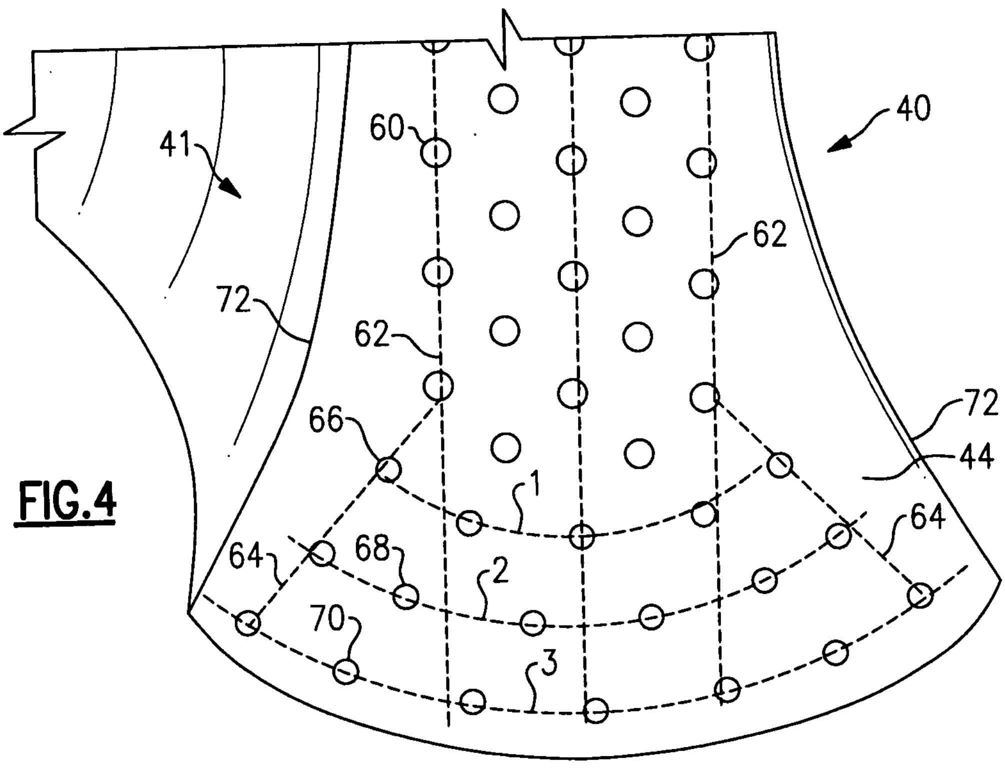

FIG.4

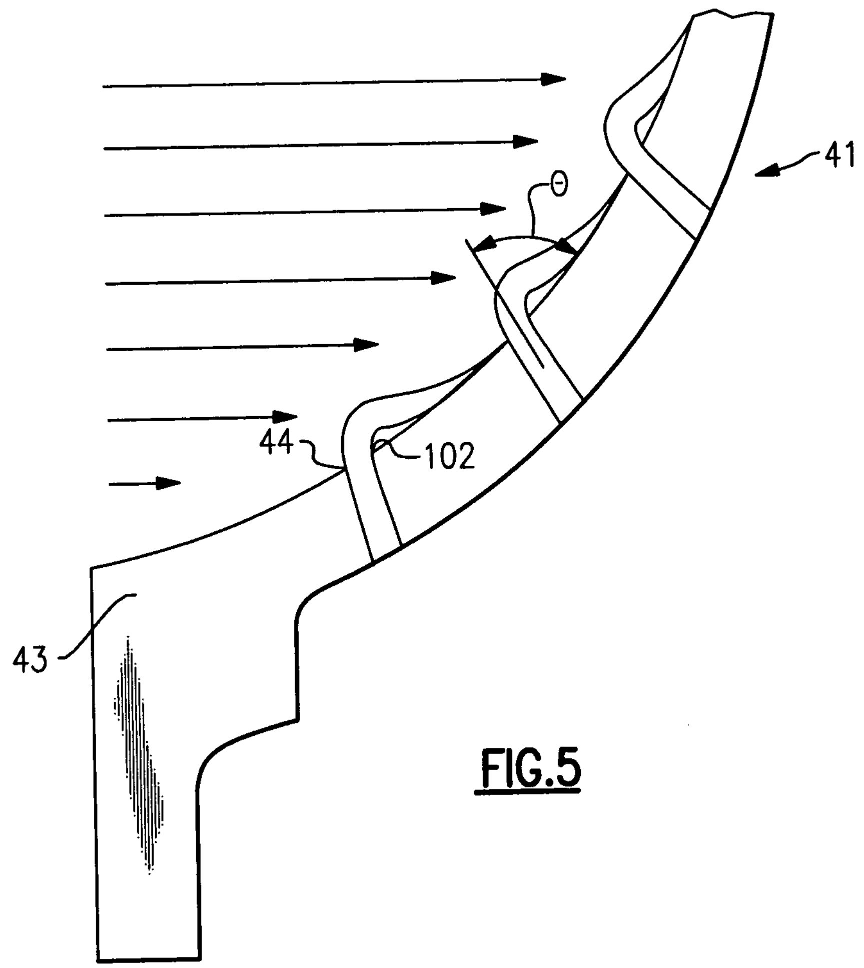

FIG.5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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- EP 1669544 A1 **[0006]**
- EP 1647672 A2 **[0006]**